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The Rationale of Suture Use

BRIEF DISCUSSIONS BASED ON REPORTS OF CURRENT RESEARCH AND CLINICAL OBSERVATION

AT NO PERIOD in surgical history has interest in the suture and various phases of wound healing been more active than at present. Through the discussion which it has promoted there is, however, reiteration of the theme that a particular type or variety of material will yield superior results under all circumstances. Nothing could be further from the truth. Uncertain, or poor results are obtained with all, and excellent results with many—*depending entirely upon the manner and circumstances in which they are used.*

Analysis of more optimistic conclusions has invariably disclosed failure to consider important contributing factors. Comparisons are made between materials without regard for marked differences in their sizes. Long-term statistics and experiences from other eras are cited without consideration of later changes in technic or improvement in the materials themselves. The effect of trauma, tension, incomplete hemostasis, and various pathologic conditions are often not accorded full significance.

This reflects no lack of sincerity on the part of the investigators. Rather it emphasizes the extreme difficulty of maintaining detailed charts and uniform control over all things in routine operative procedure, coupled with the virtual impossibility of disassociating the work from a particular set of circumstances which may influence the pattern of results.

Unfortunately, the surgeon seeking to interpret the data for application in his own work is confronted with the same difficulties and this undoubtedly explains the wide variance in clinical experience.

It is believed, therefore, that a correlation of reports from various sources, interpreted in the light of long experience in this type of investigation and supported by carefully charted experimental work, would help to clear up existing confusion. With this thought, Davis & Geck, in collaboration with recognized authorities, is preparing a series of brief discussions which will be presented in these pages from time to time.

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Selection of Material for Buried Sutures

SOME difference of opinion has always existed regarding the choice of material for buried sutures in "clean" wounds. Discussion reached its peak during the early development of the absorbable suture and practically vanished from the literature as the efficacy of catgut became generally conceded. Its recent revival through the publication of numerous observations and reports gives rise to two questions (1) Have new and important discoveries been made? (2) Has there been a widespread change of opinion on this subject?

On the basis of present evidence the answer to both queries is negative.

Scrutiny of the reports on non-absorbable materials discloses little that is new either in behavior or methods of testing. The majority refer to silk and are accompanied by statistics indicating more favorable results with it than with catgut. With few exceptions, these statistics can be immediately classified as valueless since they compare fine sizes of silk with large sizes of catgut.

The net figures are unimpressive and, at best, demonstrate only the experience of the individual or institution reporting them. They may be further discounted by the fact that for every such experience others may be cited showing similar or better results in institutions using absorbable sutures exclusively. Also to be borne in mind are the potentialities in the presence of infection, the requirements as to special technic, and the contra-indications admitted by the staunchest advocates of non-absorbable materials.

On the absorbable side there has been less promiscuous writing and most of that published has been supported by more complete and thorough research. These writers have also had an advantage in that silk has been silk for centuries and little can be claimed for other non-absorbables beyond inertness and impermeability, whereas catgut has been subject to constant improvement. Moreover, the recent development of and trend to much finer sizes, 0 to 00000, is producing new figures showing markedly improved results.

All this, however, merely serves to confirm the contention of earlier writers that although catgut was amenable to improvement, most of the difficulty was due to the manner in which it was used and the quantity introduced.

As to current general opinion—the records of manufacturers and figures available from the hospitals themselves show a preponderance in favor of absorbable sutures and little change in the percentage during recent years. Scant significance may be attached to the volume of writing on either side since obviously there is a greater incentive to write on the minority opinion than on facts which are generally recognized and conceded.

CONCLUSIONS

1. The ideal buried suture has not as yet been developed. When it is, it will probably be absorbable since absorbability offers certain advantages in most circumstances.

2. In the meantime, the importance of the materials themselves is being greatly over-emphasized. Properly used, in comparable sizes and suitable circumstances, the difference in results is negligible.

3. Improvement in the surgeon's technic and a more logical application of sutures have a more direct bearing on the subject, and growing recognition of this fact is resulting in improvement in all branches of surgery.

What Tissues Should Be Sutured?

THE usual concept of suturing is to approximate all layers, to collapse all dead space, but this should be further qualified regardless of the type of suture material employed.

Tissues to be sutured are:

- Those which tolerate sutures well.
- Those which provide the most immediate strength for the wound.
- Those which will not separate again after suturing.
- Those which protect the deeper structures from further bacterial contamination.
- Those which provide mechanical advantages other than strength.
- Those which can be approximated without tension.
- Those which are free from gross bacterial contamination.

Fasciae, ligaments, capsules of organs and the sheaths of muscles provide the greatest immediate strength for the sutured wound, are least likely to release sutures later, and tolerate sutures well. On the other hand, fat, muscle substance, and the pulp of parenchymatous organs have practically no suture strength, tolerate sutures poorly, necrotize easily, and tend to separate again after suturing.

Suturing of skin and mucous membranes protects the deeper structures from bacterial contamination, but the skin does not tolerate perforation with absorbable sutures, and mucous membranes tolerate only those which are exceedingly fine. Fine absorbable subcuticular or sub-mucosal sutures may be used successfully to approximate these structures.

Peritoneum is sutured to prevent wedging of omentum or intestines, and thus prevent a disruption of the wound or a post-operative hernia. This principle is furthered by a use of a continuous stitch.

In general, tissues are under too much tension if the cut edges cannot be approximated by a single stitch of size 0 without the suture breaking. Plastic release incisions should be employed rather than to attempt to approximate the edges with sutures of larger size.

Recent war experience has emphasized again that bacteria begin to invade traumatic wounds seven hours after infliction. Wounds in this condition should not be sutured.

The Immediate Strength of the Sutured Wound

The immediate strength of the sutured wound depends more on the character of the tissues sutured, the number of sutures used, and the manner in which they are placed in the tissues than on the thread strength of the sutures employed.

Suturing fascia provides the greatest amount of strength for the wound while the suturing of muscle and fat provides little or no strength. Increasing the number of interrupted sutures used, instead of increasing the size of the suture, produces greater wound strength. When the sutures employed pull at right angles to the major alignment of the tissue fibers, the greatest holding power of the tissues for sutures is obtained.

Although sutures lose some strength through wetting and knotting when placed in the wound, this loss is not always proportional to the original dry strengths of the sutures. Within the wound, therefore, some of the smaller sizes of sutures have strengths comparable to the larger ones. But even after this loss of strength has occurred, with wetting and knotting, the remaining or functionating strength of sutures larger than size 0 exceeds the holding power of the tissues for the sutures.

The holding power of the tissues for the sutures, then, really determines the immediate strength of the wound if sutures larger than size 0 are used. Conversely, the maximal immediate strength of the wound can be obtained by using size 0. The use of the finer size of suture will minimize the complications of wound healing often encountered with larger ones.

Bacterial Contamination at the Operating Table

METHODS of preserving the sterility of sutures during preliminary preparation and handling in the operating room are now quite generally understood, but the many opportunities for their contamination *within the operating field itself* are still too frequently overlooked.

The so-called "clean wound" is seldom completely sterile. Bacteria enter it from the air, from the respiratory tracts of the operating personnel and from the skin of the patient. Sutures may, therefore, and often do, become contaminated through repeated contact with the blood and serum of the wound as well as through contact with exposed skin.

Allowing the uninserted portion of continuous sutures to fall unnecessarily on exposed tissues, or tying interrupted sutures from long lengths of material result in progressive contamination of the strand. Ligating from a spool also leads to soiling of the material through the excessive handling it receives under this technic.

The use of individual sutures and individual ligatures provides the best assurance that the material will reach its final location in the tissues in a relatively sterile state. In any case care exercised in keeping the strand clear of the wound and its environment will be well rewarded. Likewise the sutures should be kept clear of instruments and gauze returning from the wound and the salt solution used to cleanse these instruments or to moisten the gauze.

In wounds made to drain infected foci every effort should be made to prevent contamination of the wound and the sutures with pus. Otherwise the sutures inoculate bacteria into locations in the tissues where these organisms would never have been carried by seepage. If, however, the wound edges are adequately protected with laparotomy sponges, the pus removed from the focus by suction and not allowed to flow over the wound, and if the wound is irrigated with saline to remove superficial bacteria before closure is attempted, then the sutures will not become contaminated or at least contamination will be minimal.

Knot Security

THE KNOT is the weakest point in the tied suture when considered apart from the holding power of tissues.

The thread strength of both absorbable and non-absorbable suture materials is reduced by the twisting of the strand during knotting. More important still, knots become untied with greater frequency than is generally realized and this undoubtedly accounts for a certain number of suture failures.

The type of knot and the size and type of suture material affect knot security. Moreover, recent investigations have shown that, irrespective of deftness in tying sutures and ligatures, there is considerable variation in the security of the knots tied by any one individual.

Considering all factors, the triple throw knot with all loops tied square is the safest.

The square knot is next in reliability providing both throws are firmly set. This is best accomplished by relaxing tension on the strands while making the second throw. In this way the set of the first throw will not be disturbed as the second is tied.

The surgeon's knot and the knot constructed with three strands at the end of a continuous suture are least reliable. In the former, the extra twist in the first throw prevents the second from setting securely. In the latter, the extra strand unbalances the set in both throws.

In tying any knot with one hand, the throws are less uniformly set, giving less security.

Because of increased bulk and less pliability in the strands, the knot in larger sizes of sutures cannot be pulled together as snugly as in finer sizes. The knot is therefore more secure in the finer sizes.

Leaving long ends on knots is doubtful insurance against untying and leaves an unnecessary amount of suture material in the wound. This practice should therefore be discarded in favor of the methods mentioned above for obtaining knot security.

The Mechanics of Suturing

THERE are three mechanical aspects of suturing which must be adjusted to the thread and tied strengths of sutures. These are (1) the ability of the tissues to hold tied sutures; (2) the amount of tissue tension created by suturing; and (3) the tying of the knot.

The characteristic thread strengths of sutures of all sizes and varieties are reduced by tying. Yet these tied strengths usually exceed the ability of tissues to hold them. In fact, when a sufficient number of interrupted sutures are employed, the ability of the wound edges to hold the sutures determines the strength of the wound.

When the wound edges lie together before suturing, little or no tissue tension exists. The function of the suture under these circumstances is to prevent their separation again during healing of the wound. On the other hand, when the edges of the wound are separated, approximation by sutures creates tissue tension and a constant lateral pull on the tissues at the points where the sutures pass. The wider the separation of the wound edges, the greater becomes this pull. If this pull is excessive, tissue necrosis results and the tissues lose their ability to hold the sutures.

Setting of the knot also becomes more difficult when the wound edges are separated. Therefore, if a suture breaks while being tied under this circumstance, it does not necessarily indicate that the strand has insufficient strength to hold the wound edges together. For example, size O catgut has a tied strength superior to the retentive power of most tissues, and yet the first strand or two may break when being tied under tension. The suture simply may not have a margin of thread strength sufficient to satisfy the mechanics of tying in the particular situation. The same problem may arise when a suture must be tied in a deep recess. To use a larger size may satisfy the mechanics of tying the knot, but the larger size contributes no additional strength to the wound, and in fact leaves behind an excessive amount of foreign body capable of delaying wound healing and pre-disposing to infection.

The difficulty may be obviated by first inserting one or two larger interrupted sutures temporarily to overcome tissue tension and then approximating the edges with a finer size which will really aid the process of wound healing. The temporary sutures are then removed.

Suturing Accidental Wounds in Civil and War Surgery

TWO FACTORS determine whether accidental or traumatic wounds should be sutured. These are the duration of the bacterial contamination and the amount of contused tissue about the wound.

Bacteria begin to multiply and to invade the edges of a wound after seven to ten hours. Wounds seen before this interval may be sutured without drainage, but only after irrigation and debridement. When seen after this "safe period", wounds should not be sutured but should be left open and treated as if infected. Even partial suturing of the length of such wounds, with the hope of providing some drainage and partial approximation, is absolutely contraindicated. The sutures would act only as foreign bodies and would retard healing which, under the circumstances, must occur by secondary intention anyway. They would slough out or have to be removed later.

If the edges of a wound are too widely separated to approximate, its size may be reduced by accurately suturing the angles without tension—but again only after irrigation and debridement.

Sutures should not be placed in contused tissues because infection invariably results. Moreover, insertion of sutures causes further injury which may result in complete necrosis of partially injured cells. Instead, the contused tissue should be debrided.

Complete debridement of contused tissue is not always possible, however, in traumatic wounds. In some cases the wound may be only the split in widely contused tissue. Scalp wounds resulting from falls or from blows by very blunt objects are frequently of this nature. Removal of the necessary amount of contused tissue would produce a defect impossible to close. Therefore, for such a wound a debridement removing only the foreign bodies and an approximation of the edges with adhesive plaster seems more advisable.

Suturing is usually avoided in traumatic war wounds. The bacterial contamination is often overwhelming or virulent or the wounds are seen after the safe period has elapsed and contusion is usually so extensive that more lives are saved by employing the open method of treatment with plaster immobilization. Such wounds are sutured secondarily after Dakinization. Chemotherapy is an important adjunct. These methods may also be applied in civil practice for similar circumstances.

What Size Should the Suture Be?

INSTEAD of making specific recommendations for each tissue, the basic principles underlying the selection of the proper size of suture will be discussed.

A fundamental concept is that all sutures are foreign bodies and are capable of delaying healing if used in large sizes or too abundantly. They are necessary foreign bodies, however, for if wound edges are not approximated by sutures, healing occurs by secondary intention.

How small the suture should be is determined by its ability to improve the character of wound healing. To do this, the suture may be gossamer, or at least exceedingly fine. The clean wound sutured with the smallest amount of material capable of adequately maintaining continuity has the least extensive and shortest exudative reaction. Uninjured cells begin to proliferate and the wound begins to gather strength in the shortest length of time after repair.

On the other hand, increasing the amount of suture material, particularly by using a larger size, increases the exudative reaction, provides a better foothold for bacterial growth, correspondingly delays cellular proliferation, and the wound remains weak for a longer period of time.

How large the suture should be is related to its strength and the number of sutures employed. The suture must have sufficient strength to satisfy the mechanics of insertion and tying the knot. This, however, becomes secondary if the mechanics are satisfied by the use of large sizes temporarily to relieve tension while the finer ones are being placed.

The immediate strength of the sutured wound is largely determined by the capacity of tissues to hold sutures. The strength of the wound can always be made adequate by employing enough sutures. Regardless of how fine they may be, each suture adds strength to the suture line and the capacity of the tissues to hold sutures becomes greater when the load is distributed.

The first principle underlying the selection of the suture is that it must be small enough not to interfere with early proliferation of cells after repair of the wound.

The second basic principle is that the mechanics of suturing can be satisfied and the wound given adequate strength if a sufficient number of sutures of fine size are employed.

The Ligature

THE FUNCTION of the ligature is to permanently obliterate the lumen of a blood vessel and thereby prevent hemorrhage. Behind the ligature a fibrinous clot forms almost immediately. In seven to ten days this clot becomes fibrous. Until this change occurs the danger of hemorrhage remains except in the very fine vessels.

A ligature can fail to fulfill its function for two reasons—the ligature slips before the fibrous tissue forms; or it causes necrosis and cuts through the wall of the vessel.

Any unanchored ligature, regardless of size or type of material, can slip off the end of a blood vessel unless it is tied so tightly that constriction occurs. If marked constriction occurs, necrosis takes place and the ligature may cut through producing secondary hemorrhage or an hematoma. Only transfixion of the ligature or anchoring of it to the surrounding tissue definitely assures that the ligature will remain exactly at the point where it was tied, and with transfixion the necessity for tight tying vanishes.

Whether to employ transfixion is sometimes determined by the size of the vessel to be ligated. For example, transfixion is not required if it is believed that the fibrinous clot will produce hemostasis.

The material employed for the ligature should have enough strength to satisfy the mechanics of setting a reasonably firm knot. The mechanics vary with the location of the vessel. Less traction is required to set a knot on the surface than in the depths of a cavity. Under the latter circumstance, a ligature of larger size must be used.

If a ligature is tied tight enough to cause necrosis, bacterial infection is apt to occur in the area of constriction. Ligating large tufts of tissue after crushing the bleeding points with blunt pointed hemostats also provides suitable soil for bacterial growth. Fine pointed hemostats should always be used and only the exact bleeding points clamped and ligated. When bacterial infection occurs in a wound for any reason a blood vessel may be eroded.

The method of using large, tightly-tied multiple ligatures to prevent secondary hemorrhage really is the technic to invite this complication. On the other hand, the use of fine-sized, transfixed ligatures is the best assurance against secondary hemorrhage.

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